

## CLAIMS

1.

1           A torque transducer that includes:  
2           first and second stage torsion bars connected in series,  
3           said first stage torsion bar being characterized as having a higher torsional  
4           stress in torque transmitting operation than said second stage torsion bar, and  
5           a torque sensor operatively coupled to said second stage torsion bar for  
6           measuring torque as a function of stress in said second stage torsion bar independent of  
7           said first stage torsion bar.

2.

1           The torque transducer of claim 1 further including a torsion overload shunt  
2           bridging said first and second stages for coupling the input of the first stage to the output  
3           of the second stage so that torque can be transmitted therebetween via said shunt in the  
4           event of a given differential torsional strain value being exceeded, such as occurs upon  
5           failure of either of said torsion bar stages.

3.

1           The torque transducer of claim 1 further including a failure sensor  
2           operatively coupled across the input of said first torsion bar stage and the input of said  
3           second torsion bar stage and operable to provide a sensor signal indicative of failure of  
4           either of said torsion bars.

4.

1                   The torque transducer of claim 1 wherein said first and second stage  
2                   torsion bars comprise a single integrally formed torsion bar, a first section of said torsion  
3                   bar comprising said first stage having a lesser cross sectional dimension than a second  
4                   section of said torsion bar forming said second stage.

5.

1                   An automotive steering two-stage torque sensor system that includes:  
2                   An integrally formed torsion bar having first and second torsion bar  
3                   sections respectively providing torsion bar first and second stages in series,  
4                   a first coupling for connection of the input of said first stage to a vehicle  
5                   steering wheel,  
6                   a second coupling for connecting the output of said second stage through a  
7                   steering shaft to a vehicle steering mechanism,  
8                   said first torsion bar section being constructed and arranged to have a  
9                   higher torsional stress level in torque transmitting operation than that of said second  
10                  torsion bar section and designed for providing a given steering feel at the steering wheel,  
11                  and  
12                  a torque sensor operatively coupled to said second section torsion bar for  
13                  measuring torque as a function of the stress/strain relationship in said second section  
14                  torsion bar independent of the stress/strain relationship in said first section torsion bar.

6.

1                   The torque sensor of claim 5 that further includes an overload shunt  
2                   bridging said first and second stages for coupling the input of the first stage to the output  
3                   of the second stage so that torque can be transmitted therebetween via said shunt in the  
4                   event of failure of either of said torsion bar stages.

7.

1                   The torque sensor of claim 5 further including a second sensor operatively  
2                   coupled across the input of said first stage and the input of said second stage and operable  
3                   to provide a sensor signal indicative of failure of either of said torsion bars.

8.

1                   A method of rendering a torque transducer torque sensing system fail-safe  
2                   comprising the steps of:  
3                       (a)       providing first and second torsion bar stages connected in series,  
4                       (b)       providing said first stage as one having a higher torsional stress  
5                       level in torque transmitting operation than that of said second stage, and  
6                       (c)       providing a torque sensor operatively coupled to said second stage  
7                       for measuring torque as a function of stress in said second stage independent of said first  
8                       stage.

9.

1                   The method of claim 8 further including the step of providing a torsion  
2    overload shunt bridging said first and second stages for coupling the input of the first  
3    stage to the output of the second stage so that torque can be transmitted therebetween via  
4    said shunt in the event of failure of either of said torsion bar stages.

10.

1                   The method of claim 8 further including the step of providing a second  
2    sensor operatively coupled across said first and second torsion bar stages such that said  
3    second sensor is operable to provide a sensor signal indicative of failure of either of said  
4    torsion bars.

11.

1                   The method of claim 8 wherein said first and second torsion bar stages  
2    comprise a single integrally formed torsion bar, a first portion of said torsion bar  
3    comprising said first stage having a lesser cross sectional dimension than a second  
4    portion of said torsion bar forming said second stage.

12.

1                   A method of rendering an automotive steering torque sensor system fail-  
2 safe comprising the steps of:

3                   (a)     providing an integrally formed torsion bar having first and second  
4 torsion bar stages connected in series,

5                   (b)     providing a first coupling for connecting the first stage input to a  
6 vehicle steering wheel,

7                   (c)     providing a second coupling for connecting the second stage  
8 output through a steering shaft to a vehicle steering mechanism,

9                   (d)     providing said first torsion bar stage as one having a higher  
10 torsional stress level in torque transmitting operation than that of said second torsion bar  
11 stage and designed for providing a given steering feel at the steering wheel,

12                  (e)     operatively coupling a torque sensor to said second torsion bar  
13 stage for measuring torque as a function of the stress/strain relationship in said second  
14 stage independent of such relationship in said first stage.

13.

1                   The method of claim 12 further including the step of providing an  
2 overload shunt bridging said first and second stages for coupling the input of the first  
3 stage to the output of the second stage so that torque can be transmitted therebetween via  
4 said shunt in the event of failure of either of said torsion bar stages.

14.

1                   The method of claim 12 further including the step of providing a second  
2    sensor operatively coupled across the input of said first stage and the input of said second  
3    stage and operable to provide a sensor signal indicative of failure of either of said torsion  
4    bars.